

Tables of affinity by Gauthrey, Berthollet

Explain the various diagrams used to  
show Double Salt affinity - as in  
Wronski  
& in

Wronski



chlorohydric acid, the acid will dissolve the lime before it acts on the magnesia. So likewise if sulphuric acid and a solution of the alkali soda be poured together, they will combine and form a compound having neither acid nor alkaline properties. If a solution of the alkaline earth baryta be now added, the sulphuric acid will leave the soda and unite with the baryta; this new combination will be precipitated as a white powder; and we say that the sulphuric acid has a stronger affinity for the baryta than for the soda. Trials of this kind determine the substances which appear to have the strongest affinities for sulphuric acid; and very useful tables of elective affinity are thus formed, in which the relative affinity for the substance at the head of the column, is indicated by the order in which the substances are enumerated.

239. *Double elective affinity*.—If solutions of acetate of lead and of sulphate of zinc be poured together, two new salts will be formed, sulphate of lead and acetate of zinc. The interchange is commonly said to be owing to *double elective affinity*, as the former are said to be cases of *simple elective affinity*. In the instance now given, the sulphuric acid has a stronger affinity for the oxide of lead than the acetic acid has; and it will therefore of itself decompose the acetate of lead. But there are instances of double decomposition in which this is not the case. For example, let the affinity of the acid A for the alkali C, be represented by 11, and its affinity for the alkali D, by 12. If then the affinity of an acid B for C, be represented by 8, and for D, by 11, it is evident that the combination of A with D, the force of which is 12, could not be disturbed either by the alkali C, nor by the acid B, the attraction, of which for A and for D is each represented by 11. If, however, the compound of B with C, the force of which is 8, be added to that of A with D, decomposition will

at least by Henry's  
process

take place; for the sum of the *quiescent affinities*, as they are termed, which tend to maintain the bodies as they are, is  $8+12=20$ ; and the sum of the *divellent affinities*, or those which tend to separate them and form new compounds, is  $11+11=22$ .

240. It is a consequence of the law of chemical equivalency, that in all cases of double decomposition, the resulting compounds are exactly neutralized, and that no uncombined acid or alkali remains in the solution. A few apparent exceptions will be explained in the cases where they occur.

241. It is difficult to ascertain what decompositions and combinations take place in mixed solutions, where all the compounds that can be formed are soluble. Sulphuric acid will separate the last particle of boracic acid from its combination with soda, although the whole of it remains in solution. And yet it seems probable that two soluble salts generally co-exist in proportions regulated by their respective affinities.

242. If one of the resulting salts be insoluble, it will in every case, be formed. If any one of the salts A D, for instance, be less soluble than the other, and the solution be evaporated until this salt crystallize so as to diminish its relative proportion, an additional portion will be formed; and by continuing the process all the acid will combine with the alkali D. The salts which are obtained by the evaporation of dilute solutions are therefore not necessarily those which it originally contained; for new combinations will take place, as we pass the point of saturation of the several salts whose elements thus co-exist in the solution.

243. *Change of properties by Combination.*—The combination of elements that differ much in their electrical relations, that is to say, one of which is highly negative to the other, is always accompanied with so great a change of properties, that the result-

Explains

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ing compound must be placed in a different class and be called by a new name. When the elements approximate to each other, in their general character and electrical condition, there are many cases in which the resulting compound appears merely to blend or slightly modify the properties of its elements, and to belong to the same class of bodies in a philosophical arrangement. Thus the chloride of iodine, the iodide of bromine, and the sulphuret of phosphorus, are neither acid nor alkaline, but are supporters of combustion, or combustible like their elements. The metals eminently possess this character in their combinations with each other; and the compounds, or *alloys*, as they are termed, formed by their fusion and intermixture, acquire no new generic qualities, but possess all the properties of metals.

244. *Extrication of Heat and Light.*—The combination of the simple elements, which differ greatly in their electrical relations, is in general accompanied with the copious extrication of heat and light, the source of which is not known. *By electricity*

The most common instance of this is the combustion of inflammable bodies in oxygen gas. When a portion of the body is raised to the temperature at which combination takes place, the heat that is extricated is sufficient to raise an additional portion to the same temperature, and thus the combination goes on until the whole body is consumed. Where the combustible is a compound, which is resolved at this temperature into gaseous elements, it burns with a flame. These results are beautifully shown in the burning of a common oil lamp.

245. In the case of gunpowder, the inflammation is propagated so rapidly through the whole mass, and the volume of the gaseous products of the combustion thus suddenly formed is so great, as to render that substance one of the most tremendous engines of destruction known to man.

*Least by Henry's  
present*

246. The union of binary compounds with each other is seldom accompanied with the extrication of much heat or light, and the more complex the body, with the greater facility does it in general change its combinations.

247. *Force of Chemical Union.*—The stability of chemical compounds varies exceedingly. The elements which are most firmly united are those forming binary compounds, and differing greatly in their electrical conditions. The most intense heat and the most powerful re-agents are scarcely able to separate the elements of some of the chlorides and oxides.

248. In general the ease with which decomposition takes place, increases with the increase of one of the elements. Thus nitric acid is much more easily decomposed than the deutoxide of nitrogen; and the metallic per-oxides readily yield up the second and third atoms of oxygen, while they part with difficulty with the first.

249. *Molecular agitation a cause of Decomposition.*—On the other hand the per chloric acid, which contains 7 atoms of oxygen, is decomposed neither by hot chlorohydric acid, nor by organic substances; while the protoxide of chlorine is one of the most unstable compounds in existence, being decomposed by the molecular agitation caused by mere expansion.

This instability of composition is still more remarkable in the fulminating salts of the metals. The slight friction of a grain of sand against a single particle of fulminating silver, will be sufficient to cause a new arrangement of its elements, which instantaneously assume a gaseous form; and the impulse thus given is propagated through the whole mass with the rapidity of lightning.

250. In these cases the forces which hold the atoms together are so slight, the *divellent* so nearly balance the *quiescent* affinities, that the chemical equilibrium

Explains

gun  
caps

W. H. C.



seems to be maintained by the mere vis inertiae of the particles. Whatever cause disturbs this and sets the atoms of a single particle in motion, decomposes that particle, motion is communicated to the adjoining, and the decomposition is propagated with more or less rapidity through the whole mass.

251. There are cases of combination in which the quiescent affinities are so nearly balanced by the divellent, that the presence of a second body may effect the decomposition of the first, while at the same time the molecular agitation, which takes place so disturbs the equilibrium of the particles in the decomposing body, and the heat generated is so great that it also is decomposed. In no other way can we understand what takes place when oxide of silver is added to deutoxide of hydrogen. The latter is rapidly decomposed, oxygen escapes, and water and metallic silver remain.

252. Examples of this law are of constant occurrence. If a dilute solution of a salt of potassa be carefully added to one of tartaric acid, and the mixture remain perfectly quiet, no change takes place. But if it be briskly agitated, the motion thus communicated to the particles is sufficient to destroy the equilibrium, and produce a new arrangement, and crystals of bi-tartrate of potassa are immediately formed. These cases somewhat resemble the forced equilibrium of the particles of glass in what are called *Prince Rupert's Drops*. These are formed by letting drops of melted glass fall into cold water. The external particles are at once solidified and their contraction forces the still soft and yielding interior mass, into a smaller space than the gradual cooling of the whole would have allowed it to occupy. It is therefore kept in a state of tension, which acts as soon as the external is removed; so that if the least fragment be broken off the small end, the whole drop is shivered into small fragments. explains



253. *Influence of the presence of a third body.*— There are cases in which an influence not sufficiently understood is exerted by the presence of a third body. Zinc slowly decomposes water, and concentrated sulphuric acid does not attack zinc; yet when the three are mixed, the water and the zinc are acted on with the greatest energy. In this case the sulphuric acid probably acts by dissolving the thin film of oxide, which forms on the surface of the zinc, and keeps the metal bright, thus promoting the decomposition of the water, which is further aided by the heat, generated by the chemical action.

254. Platinum in a state of minute division may be immersed in boiling nitric acid, without the slightest chemical action; while its alloy with silver is readily dissolved. In this case the silver is oxidated by the decomposition of the nitric acid, and the platinum, in the act of being set free from its combination with the silver, being in what is called its nascent state, also combines with oxygen and forms a salt with nitric acid.

255. Many substances which in their ordinary state, exhibit feeble traces of affinity for other bodies, and which can scarcely be made to unite with them, readily enter into combination, when they are presented in what is called their *nascent state*, that is to say, when existing combinations are decomposed and elements, capable of uniting into new compounds are disengaged. It is with extreme difficulty for instance, and but in small quantities, that nitrogen can be directly combined with hydrogen gas. Yet ammonia, which is their most stable compound, is always copiously formed when animal bodies which contain them both are decomposed.

256. The combination of gases which have an affinity for each other is greatly promoted by the presence of certain bodies, such as oxygen and hydrogen, may be kept together in a glass vessel, for an indefinite time, without any disposition to

*W. H. C.*

unite. Yet if a piece of platinum foil be placed within the vessel, drops of water will make their appearance on the sides, and the two gases will gradually combine together. This combination takes place so rapidly when the platinum is in a finely divided state, such as is obtained by precipitation, that the metal becomes red hot, and the gases explode. By the same agency, the combination of many other gases may be effected. Many porous bodies, such as powdered glass, pumice stone, charcoal, &c., possess this property at the temperature of  $200^{\circ}$ , or  $300^{\circ}$ .

257. The union in these cases seems to be effected by an adhesion of the gaseous particles to the surface of the solid body, similar to that of certain liquids to solids, so that their mutual affinities are brought into play. The phenomenon appears to confirm the theory of Dalton, that the repulsive force of the particles which constitutes a gas, like the cohesive force which constitutes a solid, obtains only between homogeneous particles, and that the different gases so far from repelling, are mutually indifferent to, each other.

258. *Absorption of gases by Solids.*—In other cases the adhesion above spoken of causes a copious absorption, analogous to liquefaction. Thus a cubic inch of charcoal will absorb 90 cubic inches of ammoniacal gas, which it gives out again when heated. We cannot but conceive the gas in this case, to be held adhesively in a liquid state, amidst the pores of the charcoal.

259. *Solvent power of Fluids.*—The most simple instance of the exercise of chemical attraction is afforded by the admixture of two fluids, such as water and sulphuric acid, water and alcohol; or by the solution of a solid, as of sugar in water, or camphor in oil.

In some cases a mixture of fluids, and of

the solution of solids in fluids, the proportions in which they unite appear to be unlimited. Water and alcohol, gum and water, and camphor and alcohol, for example, will combine in all proportions. There are other cases in which the union takes place in all proportions up to a certain limit. One hundred grains of water, for example, will dissolve any quantity of sea-salt which does not exceed forty grains. Its solvent power then ceases, and it is said to be saturated. The solvent power of a liquid is in most cases, though not always, increased by heat. Substances which unite in unlimited proportions, or in all proportions up to a certain limit, give rise to compounds which have this common character, that their elements are united by a feeble affinity, and preserve, when combined, more or less of the properties which they possess in their separate state.

260. *Influence of cohesion.*—Solid bodies seldom act upon each other, as chemical affinity is exerted only at insensible distances, and the particles of solids do not come within the sphere of each other's attraction. Fluids oppose no obstacle to the action of chemical affinity, and whether a solid is rendered liquid by increasing the heat, or by dissolving it in some menstruum, it is in this state that chemical affinity acts with its whole energy. Bodies which do not unite with each other when they are intimately mixed in a fluid state, possess little or no affinity for each other.

The fluidity of one of the bodies is often sufficient for effecting chemical union, as in the case of sugar, or salt, and water.

261. *Influence of Elasticity.*—When an elastic fluid enters into the decomposition of a solid or liquid body, its elasticity tends to counteract the effect of chemical affinity, and the compound will be decomposed by a third body, though actually a weaker affinity for the second than the first. As vessels

any d

+ Change of colour

Sol: Sulph<sup>r</sup> & Colch<sup>r</sup> &  
Liquid Ammonia  
Sulph<sup>r</sup>: acid to discharge

Orange - Sol Corrosive sublimate  
add sol<sup>n</sup> Potash

Black Sol Sulph<sup>r</sup> Iron  
Trinitro Gal<sup>s</sup>

Blue Sol Sulph<sup>r</sup> Iron  
Purple Potash

Red - Trinitro Nitro  
dilute Muric acid

Purple Trinitro Nitro  
Liq<sup>d</sup> Ammonia

Green Red cabbage Water  
& alkali

Brown Trinitro Ammonia  
and alkali

Gas Solid - fumes of liquid  
ammonia & Muric acid

Solids Solid consent Sol Muric acid  
of fumes - add Sulph<sup>r</sup>: acid

Sol Sol Epsom salt and  
sol Cambric Potash

Solids Gasous Cyanogen

Solids to Liquid . Trinitro Nitro  
of Ammonia & Glauber's salt,



The volatility of certain substances affords a ready method of separating them from their combinations. Alcohol and water have an affinity for each other, but the former is volatile at a much lower temperature than the latter, and may be almost entirely separated from it by heat.

262. *Change of Density.*—Two bodies rarely occupy, after combination, the space which they took up separately. In general, the density of the compound exceeds the mean density of its elements. For example, 100 measures of water and an equal quantity of sulphuric acid, or of alcohol, do not occupy 200 measures. The alloys of metals generally have a greater density than the mean of the simple metals of which they are formed.

This is still more remarkably the case with the gases. Many gases combine without undergoing any change of volume. But in the greater number of cases a very great condensation occurs, and the volume of the resulting compound bears a very simple ratio to the volume of its elements; this will sufficiently appear from the following table, in which all the substances are supposed to be in the gaseous state.

Volumes of Elements.	yield	Volume of resulting compound.
100 N+300 H	200 ammonia,	
50 O+100 H	" 100 water,	
50 O+100 N	" 100 protoxide of nitrogen,	
100 S+600 H	" 600 sulphohydric acid,	
100 S+600 O	" 600 sulphurous acid,	
100 Cl+100 H	" 200 chlorohydric acid,	
100 I+100 H	" 200 iodohydric acid,	
100 Br+100 H	" 200 bromohydric acid,	
100 O+100 N	" 200 deutoxide of nitrogen.	

263. *Change of Form.*—A change of form frequently accompanies chemical combination. The combination of gases may give rise to solids or liquids; solids sometimes become liquid, and liquids

*In the  
Electrical classification  
before referred to &  
which hereafter you  
will find very  
extensively used  
all things which  
contain or consist  
of two elements only.*



## + Change of Colour

Sol: Sulph<sup>ic</sup> Cobalt &  
Liquid Ammonia  
Sulph<sup>uric</sup>: acid to discharge

Orange - Sol Corrosive La  
add Sol: Potash

Black Sol Sulph<sup>uric</sup> Iron  
Friction of cells

Blue Sol Sulph<sup>uric</sup> Iron  
Purple Potash

Red - Friction Lithium  
dilute Muric acid

Purple Fine Lithium  
Liq<sup>ueur</sup> Ammoniac

Green Red cabbage Water  
& alkali

Brown Lithium Ammoniac  
and alkali

solid. When in consequence of chemical combination, solids or liquids suddenly become gases, detonation takes place; when a gas and a liquid are formed, the escape of the former through the latter gives rise to effervescence, and when a solid and a liquid are formed, the deposition of the former is called precipitation.

All these changes of density and form in chemical combination are accompanied with a change of temperature, the causes of which have been explained in the chapter on caloric.

+ 264. *Change of Colour.*—Chemical action is often accompanied with change of colour, and no law regulating this change has yet been discovered. For example, iodine, the vapour of which has a violet colour, forms a red compound with mercury, a yellow compound with lead, and colours starch blue.

265. Such are the principal laws which govern chemical combination. In the chapter on salts, and in that on compound radicals, the subject will be resumed, and the principles which regulate the constitution of highly complex bodies, will be further developed.

In treating of compound substances it will be convenient first to consider the bi-elementary compounds, ranging them into genera, under the heads of their electro-negative element.

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 CHAPTER III.

## BI-ELEMENTARY COMPOUNDS.

266. The compounds which are formed by the union of two simple elements may be designated as binary compounds of the first order. They contain several very natural groups, such as acids, alkalis, earths, the haloid salts, and alloys.

*Show the Elect. Table*

267. *Principles of Classification.*—The elements themselves, as has been stated, may be arranged according to their electric relations; with oxygen, the most highly electro-negative, at one end of the scale, and potassium, the most highly electro-positive at the other. If such a table could be formed with entire accuracy, each element would be electro-negative to all below and electro-positive to all above it in the scale.

The binary compounds may be classed in genera according to their electro-negative element. The most obvious arrangement would be according to their sensible properties as acids, alkalis, &c.; but as these sensible qualities depend upon, and are controlled by their electrical relations, the latter must be adopted as the higher principle of classification.

268. *Acids.*—The earliest definition of an acid was, that it is a substance of a sour taste, which turns vegetable blues red, and forms neutral salts with alkalis. Lavoisier added to the definition that it must contain oxygen as an element; and the class was gradually enlarged by the addition of bodies which have a bitter, and even a faintly sweet taste. Further research compelled chemists to admit into the class some bodies which contain no oxygen, others which do not affect vegetable blues, and others which are quite tasteless, until at last the only part of the original definition that is retained, is that they neutralize alkalis; a definition which is merged in the more comprehensive one now given, that they neutralize electro-positive compounds of the same genus, and are the electro-negative element of the compounds which they form.

269. *Bases.*—In the same manner, has the number of those bodies which acids are capable of neutralizing, been enlarged. Although chemists have been led to the inconvenient retention of the word acid, the common use of which is so different from its philosophical meaning; they have, by the adoption

*In the  
Electrical classification  
before referred to &  
which hereafter you  
will find very  
extensively used*

*all things which  
contain or consist  
of two elements only.*

+ Change of colour

Sol<sup>n</sup>: Sulph<sup>ur</sup> Cobalt &  
Liquid Ammonia  
Sulph<sup>uric</sup> acid to discolour

Orange - Sol Corrosive Sol  
and Sol<sup>n</sup>: Potash

Black Sol Sulph<sup>ur</sup> Iron  
Ferrous Salt

Blue Sol Sulph<sup>ur</sup> Iron  
Purple Potash

Red - Ferrous Sulph<sup>ur</sup>  
dilute Musc<sup>ic</sup> acid

Purple Zinc Sulph<sup>ur</sup>,  
Liq<sup>d</sup>: Ammonia

Green Red Cabbage Water  
& alkali

Brown Zinc Iron  
and alkali

of the term *base*, happily rid themselves of the like inconvenience in speaking of those bodies with which acids combine. The term *base*, is used to express all those electro positive compounds which are capable of combining with electro-negative ones, (generally of the same genus) and which, in so combining, acquire new generic properties. This extension of the meaning of the term *base*, has given a corresponding extension to the antagonist term *acid*.

270. *The Haloid Salts*.—The term salt, like the term acid, carried with it into philosophy its popular meaning, and here also it has been found necessary to extend its meaning, so as to admit substances which possess no sensible saline properties. Restricted, originally, as was believed, to the combination of an acid with an alkali, it has been found that the most eminently saline of the whole class, contain neither acid nor alkali, but are direct binary compounds of metals with certain electro negative elements.

This group of salts is called, by Berzelius, the Haloid Salts, and consists of the metallic compounds of the *Salt-Radicals*—Chlorine, Iodine, Bromine, and Fluorine.

271. The bi-elementary compounds will here be classed under the following heads; viz: Oxides, Chlorides, Iodides, Bromides, Fluorides, Sulphurets, Phosphurets, Carburets, and Alloys.

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## SECTION I.

### THE OXIDES.

272. The oxides form several well defined groups. The non-metallic elements, are all placed at the negative end of the scale, and their oxides are, with

By the  
Electrical classification  
before referred to &  
which hereafter you  
will find very  
extensively used

all things which  
contain or consist  
of two elements only.

Chloride of Sodium

— of Gold & Platinum



+ The leading character of these compounds is derived from the circumstance that Chlorine & Oxy<sup>n</sup> the attacks of which for most elementary substances is so energetic, have but a feeble affinity for each other, perhaps because both are Electro negat<sup>s</sup>.

Discovered by Davy in 1811 & called by him Euchlorine  
1 Cl + 1 Ox  
Ev very, χροπος green

More easily from Chlorate of Potassa distilled by very gentle heat with half a half dilute chloro hydric acid, in a tube about 1/2 inch diam<sup>r</sup> in water bath under 2 1/2 l the gas is? over the mercury - Great caution & wooden tong<sup>s</sup> are necessary, as the heat of hand is sufficient to explode the gas with great violence. At first it was deemed a protoxide, but produces salts of electro pos basis & is therefore an acid

then from  
Oxygen an  
imperfect form



+ 50 grains Chlorate Potassa mixed with small quantity of concd Sulph<sup>ic</sup> acid becomes a solid yellow mass This introduced into a very small glass vial or bent tube & heated by water & alcohol under 21<sup>st</sup> at wh<sup>ch</sup> it explodes violently.

the exception of a few protoxides, the electro negative elements of a series of secondary compounds, and constitute the most numerous class of acids. The non metallic protoxides, which are not acids, do not appear to act the part of bases. If we regard hydrogen as a gaseous metal, which its chemical relations authorize us to do, there will be no exception to this rule.

Fluorine is the only element which has not yet been combined with oxygen.

273. Oxygen forms, with the metals at the positive extremity of the scale, a series of protoxides, having well marked characters. The protoxides of potassium, sodium, and lithium, are alkalies; those of barium, strontium, calcium, and magnesium, alkaline earths.

These protoxides are all powerful electro positive bases. The alkalies are distinguished by their great solubility in water, by a peculiar acrid taste, by turning vegetable blues green, and vegetable yellows brown, and by forming compounds soluble in water with oils. The alkaline earths have these properties in a less degree; baryta being the most, and magnesia the least alkaline of the series. A few of these metals form deutoxides and teroxides, which do not appear to possess either basic or acid properties.

The metals which rank next below these in the scale, are the bases of the earths, glucina, yttria, thorina, alumina, and zirconia; their oxides are characterized by tastelessness, insolubility, and difficult fusibility. But one oxide of each of these metals is known.

The highly basic properties of water, place it near the group of alkalies and alkaline earths, to the peroxides of which, the peroxide of hydrogen has also much analogy.

274. With most of the remaining metals, oxygen forms several oxides, of which the lower degrees of

95

It has not been applied to any practical use

Chlorate of Potassa  
It forms the chlorates  
formed by hyper oxygen

oxidation are more or less basic, and the higher degrees are either indifferent to acids and to bases as the deutoxide of lead, or acid as the teroxides of chrome and manganese. The tendency to form acids with oxygen, is greatest in those metals which are nearest the electro negative end of the scale.

It will be most convenient to arrange the oxides into sub orders, corresponding with the above distinctions.

*Sub-order First.*

NON METALLIC OXIDES. 22/161  
metals

OXIDES OF CHLORINE. +

‡ 275. Protoxide of Chlorine, Hypochlorous Acid. Cl O.  $35.42+8=43.42$ . This acid is prepared by the agitation of finely powdered deutoxide of mercury with water in a bottle of chlorine gas. The gas is absorbed by the peroxide, a portion of which it decomposes. One portion of the chlorine unites with the mercury, and another with the oxygen that has been set free, forming hypochlorous acid, which is dissolved by the water. Pure hypochlorous acid is a gas of a pale yellow colour. Its concentrated solution has a flash of sour acid, but not sour taste; and its odour is penetrating, somewhat resembling that of chlorine. It bleaches like chlorine, and destroys the epidermis like nitric acid. It is one of the most unstable compounds known. Its concentrated solution spontaneously decomposes, and the gas explodes with a flash of light when the temperature is slightly raised. Two volumes expand into three, of which one is oxygen, and two are chlorine. The hypochlorous acid combines with bases to form salts, which are remarkable for their bleaching properties.

276. Peroxide of Chlorine. Chlorous Acid.—Cl O<sub>2</sub>;  $35.42+32=67.42$ . This acid is prepared by carefully adding dilute sulphuric acid to chlorate of

*Davy 1815*

+ The leading character of these compounds is derived from the circumstance that Chlorine & Oxy<sup>n</sup>: the attraction of each for most elementary substances is so energetic, have but a feeble affinity for each other, perhaps because both are electro negat<sup>ve</sup>:

‡ Discovered by Davy in 1811 & called by him Euchlorine  
1 Cl + 1 Ox  
Ev very,  $\chi\lambda\omicron\pi\omicron\varsigma$   $\gamma\epsilon\mu\alpha$

○ more easily from chlorate of Potassa distilled by very gentle heat with half a half dilute chloro hydric acid, in a tube reboiled in a water bath under 21<sup>st</sup> of the gas rec<sup>d</sup>: over the mercury - great caution & wooden tongs are necessary, as the heat of hand is sufficient to explode the gas with great violence. At first it was deemed a peroxide, but produces salts at electro pos basis & is thus form an acid

+ 50 grains Chlorate Potassa mixed with small quantity of concd Sulph<sup>r</sup> acid becomes a solid yellow mass This introduced into a very small glass retort or bent tube & heated by water & alcohol under 21<sup>st</sup> at wch it explodes violently.

CHLORIC ACID.

139

potassa. The chloric acid, in being disengaged from the potassa, is itself decomposed, and every three atoms which are set free, form two of chlorous, and one of per chloric acid.

Chlorous acid is a gas, of a bright yellowish green colour, and an aromatic odour; it is rapidly absorbed by water, it has no action on mercury, it does not combine with the alkalis, and it destroys most vegetable colours. Phosphorus takes fire in this gas, causing an explosion; it explodes violently when heated to 212°, emitting a strong light. Forty measures occupy after explosion the space of 60 measures, of which 20 are chlorine and 40 oxygen, so that it is composed of 100 measures of chlorine and 200 of oxygen, condensed into 200 measures; its specific gravity is therefore 2.3374.

Chlorous acid gas is condensed by pressure into a yellow liquid. It forms salts with alkalis, which are speedily decomposed into chlorates and chlorides.

277. Chloric Acid.—Cl O<sub>3</sub>; 35.42+40=75.42. This acid may be obtained in solution, by the careful decomposition of a dilute solution of chlorate of baryta by sulphuric acid. It reddens vegetable blue colours, has a sour taste, and forms neutral salts called chlorates. It may be distinguished from chlorine by being destitute of bleaching properties, and from chlorohydric acid by not occasioning a precipitate in a solution of nitrate of silver. The solution of chloric acid may be concentrated by a gentle heat, until it acquires an oily consistence, when it has a yellowish tint, and the odour of nitric acid, and sets fire to paper and other dry organic matter. Chloric acid may be known by its property of forming with potassa a salt of a pearly lustre, which crystallizes in tables, and deflagrates on burning charcoal like nitre.

Chloric acid closely resembles nitric acid in its properties. It has never been obtained in an isolated form, being incapable of existing except in combination with water or a base.

It has not been applied to any practical use

Chlorate of Potassa  
It forms the Chlorates  
formed by Hyper oxyg. Acids



278. *Per Chloric Acid.*— $\text{ClO}_7$ ;  $35.42+56=91.42$ . This acid is prepared from the perchlorate of potassa, by mixing it with half its weight of sulphuric acid, and heating the mixture; white vapours arise which condense in the receiver into a colourless liquid. Its concentrated solution has the specific gravity of 1.65, fumes lightly in the air, and boils at  $392^\circ$ . By distillation with sulphuric acid, in order to separate the superfluous water, a solid hydrate may be obtained in prismatic crystals. Like the chloric acid, it exists only in combination with water or other bases. It is the most stable of the oxides of Chlorine. It does not possess bleaching properties, and is one of the most powerful re-agents among the acids.

## OXIDES OF IODINE.

279. *Iodic Acid.*— $\text{IO}_3$ ;  $126.3+40=166.3$ . This acid is formed when iodine is brought into contact with protoxide of chlorine. It is a white semi-transparent solid, with a strong astringent, sour taste, and no odour. Its density has not been ascertained, but it sinks rapidly in sulphuric acid. It fuses and is decomposed at  $500^\circ \text{F}$ . It detonates when mixed with inflammable organic substances, is deliquescent and very soluble in water, and forms salts which deflagrate like nitre.

280. *Periodic Acid.*— $\text{IO}_7$ ;  $126.3+56=182.3$ . This acid is analogous in its composition to per-chloric acid, though little is known of its properties.

## OXIDES OF BROMINE.

281. *Bromic Acid.*— $\text{BrO}_3$ ;  $78.4+40=118.4$ . Bromic acid closely resembles chloric acid. Its solution cannot be concentrated beyond a certain point without undergoing decomposition. It is the only known oxide of bromine.

## OXIDES OF SULPHUR.

282. *Sulphurous Acid.*— $\text{SO}_2$ ;  $16.1+16=32.1$ . Sulphurous acid is the sole product of the com-

+ The leading character  
from these compounds is due  
from the circumstances  
Chlorine & Oxygen the at  
of each for most elements  
Substances is so every  
have but a feeble affe  
for each other, perhaps  
because both are electro neg

Ediscon? by Davy in 1811  
called by him Euc  
1 ch + 1 ox  
Ev very, xpoos

○ more easily from Chlor  
of Potassa distilled by  
gentle heat with half  
half dilute chloro by  
acid, in a tube set  
1/2 inch diam. in a  
bath under 212 & the  
res? over Mercury -  
cations & wooden tong  
necessary, as the heat  
hand is sufficient to  
the gas with great  
at first it was deemed a  
oxide, but produces so  
electro pos base & is then  
an acid

+ 50 grains Chlorate Potash mixed with small quantity of Conc'd  
Sulp. acid becomes a solid yellow mass This introduced into  
a very small glass retort or bent tube & heated by water &  
alcohol under 21°  
at which it explodes  
violently.

has not been applied  
to any practical use.

Chlorate of Potash  
It forms the Chlorate  
formed by Hyper oxyg. muriatic

one of the feeblest of the acids, is always  
produced when Sulphur is burnt in  
open air



\* For sulphur will not under any circumstances take up more than 2 atoms of  $O_2$  in the first instance; and in all the other forms of the acid of sulphur, the sulphid acid is found preexisting. There is good reason for believing that  $SO_2$  is the only direct compound of these 2 elements & that 2 atoms of  $O$  fully saturated of  $S$  sulphid acid appears therefore to ~~be~~ <sup>result from</sup> one of those compound radicals of which we shall have many instances, as we proceed, and which are capable of uniting with other simple & compound bodies. Sulphid acid therefore is not  $SO_2$  but  $SO_2 + O$

used for bleaching Glass hats  
& Wollen goods

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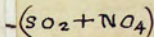
283.  
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bustion of sulphur in dry oxygen gas. The best method of obtaining it is by the action of sulphuric acid on mercury. When two parts of mercury and three of sulphuric acid are gently heated in a glass retort, the mercury is oxidated at the expense of a part of the sulphuric acid which is converted into sulphurous acid gas, that must be collected over mercury.

At the usual pressure and temperature sulphurous acid is a permanent gas, of the specific gravity of 2.2117, and of a suffocating, pungent odour; it extinguishes burning bodies without being itself inflammable, and is fatal to animal life.

Water dissolves 33 times its volume of this gas, and acquires its peculiar odour. The gas may be expelled unchanged by heat, but it is gradually converted into sulphuric acid by the absorption of oxygen from the water. Sulphurous acid bleaches most vegetable colours, without decomposing the colouring principle, for the colour may be restored by an alkali or stronger acid. It absorbs oxygen from water, nitric acid, and many other substances, and is converted into sulphuric acid; and it is, on the other hand, produced by the de-oxidation of sulphuric acid. It may be passed through red hot tubes without change, but is decomposed at a red heat by hydrogen, carbon, and potassium. Sulphurous acid liquefies under a pressure of two atmospheres. The liquid acid has a specific gravity of 1.45, and boils at 14° F.

283. *Sulphuric Acid.*— $\text{SO}_3$ ;  $16.1+24=40.1$ . Sulphuric acid is a tough, elastic, white crystalline solid; which liquefies at 66° F., and boils at 104° to 122°, forming, when there is no water present, a transparent vapour. This anhydrous acid has a powerful affinity for water; it emits dense white fumes in a moist air, and unites with an atom of water, forming the well known oil of vitriol, which is a liquid sul-



How kept: by water of life

\* For sulphur will not under any circumstances take up more than 2 atoms of oxygen in the first instance; and in all the other forms of the Acid of sulphur the sulphuric acid is found holding that 2 elements & Sulphuric acid compound in many instances capable of existing in bodies. Sulphuric acid

phuric acid, composed in its most concentrated state, of 1 sulphuric acid 40.1+1 water 9=49.1. When the vapour of this anhydrous acid is brought into contact with the dry alkaline earths, they combine with brilliant incandescence, and form the sulphates of these earths.

284. The sulphuric acid of commerce is prepared in two ways. The first is by decomposing the protosulphate of iron by heat. The salt is dried until it loses all its water of crystallization, and is then exposed in proper vessels to a red heat, which expels all its acid. This is the process pursued at Nordhausen in Germany, and the acid thus prepared is a dense, oily, brownish liquid, of the specific gravity of 1.9, which emits copious white fumes, and is known by the name of fuming sulphuric acid. By careful distillation, in a retort connected with a receiver surrounded by snow, a transparent vapour passes over and condenses into the tough crystalline mass already mentioned as anhydrous sulphuric acid. The liquid remaining in the retort is common oil of vitriol, so that the Nordhausen acid is a compound of the two, consisting, according to Dr. Thomson, of one atom of anhydrous, and one of hydrated acid.

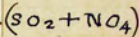
285. The usual method of manufacturing oil of vitriol, is by the combustion of a mixture of eight parts of sulphur and one of nitrate of potassa. This is burnt in a furnace so contrived that the current of air which supports the combustion carries the products into a large leaden chamber, the bottom of which is covered to the depth of several inches with water. The nitric acid of the nitrate is decomposed, by the heat of the burning sulphur, into oxygen and deutoxide of nitrogen. The former supports the combustion, and the latter, uniting with the oxygen of the atmosphere, is converted into nitrous acid, and carried along with the sulphurous acid, into the

chamber. They here combine with the vapour of water into a crystalline compound, which is deposited on the walls of the chamber and in the water. By contact with water this crystalline compound is converted into sulphuric acid and deutoxide of nitrogen, the latter of which is reconverted into nitrous acid by the oxygen of the atmospheric air in the chamber, and combines with the sulphurous acid and vapour into the same crystalline compound, again to be decomposed into sulphuric acid and deutoxide. In this manner the whole of the sulphurous acid is converted into sulphuric. When the water in the chamber is sufficiently charged with acid it is drawn off and concentrated by boiling in leaden and glass vessels, until it has gained the density requisite for strong oil of vitriol.

286. Hydrated sulphuric acid, or oil of vitriol, is a dense, colourless, oily fluid, which boils at  $620^{\circ}$  F., has a specific gravity varying from 1.847 to 1.85. It is one of the strongest of the acids, separating all the others more or less completely from their combinations with the alkalis. It decomposes all vegetable and animal substances by the aid of heat. It has a strong acid taste, and reddens litmus paper even when very much diluted.

Sulphuric acid has a powerful affinity for water, extricating much heat during the combination, and forming several definite hydrates with it. When a dilute acid is evaporated at  $400^{\circ}$ , it acquires a specific gravity of 1.78, and becomes a hydrate containing two atoms of water, which solidifies at  $32^{\circ}$ , forming large regular crystals that remain solid at  $45^{\circ}$ . By evaporating a still more dilute acid at  $212^{\circ}$  in vacuo, a third hydrate is formed, having a specific gravity of 1.632, and containing three atoms of water. These hydrates appear to form distinct classes of salts.

287. When the vapour of sulphuric acid is passed



How kept by weight



\* For sulphur will not under any circumstances take up more than 2 atoms of  $O_2$  in the first instance; and in all the other forms it is believed that the sulphuric acid is formed believing that 2 elements & Sulphuric acid compound many instances capable of bodies. Sul

through a red hot porcelain tube, it is decomposed into two volumes of sulphurous acid, and one volume of oxygen.

288. There are two other acids of sulphur; the hyposulphurous  $S_2O_2$ ;  $32.2+16=48.2$ , and the hyposulphuric  $S_2O_4$ ;  $32.2+40=72.2$ . The former is a very unstable compound, and is remarkable for forming with silver a salt of an intensely sweet, without any metallic taste.

289. There is solid ground for believing that sulphurous acid is the only one of the above oxides that is a direct compound of sulphur and oxygen, and that it is the base of all the others. It is the only one which can be directly prepared from its elements, and it is always evolved in the decomposition of the others. On this view the sulphur in sulphurous acid is fully saturated with oxygen, and cannot unite with any more; but the acid itself acts as a compound radical, and combines with simple and compound bodies. It does not unite directly with oxygen, but it does so with nitrous acid, and the compound is decomposed by water, and produces sulphuric acid  $SO_2+O$  as detailed above. It combines with sulphur to form hyposulphurous acid  $SO_2+S$ , which is a true sulphur acid. Two atoms combine with oxygen to form hyposulphuric acid  $S_2O_4+O$ . It also combines with chlorine to form chloro sulphurous acid  $SO_2+Cl$ , with iodine to form iodo sulphurous acid  $SO_2+I$ , and with nitric oxide to form nitro sulphurous acid  $SO_2+NO_2$  (Kane).

## OXIDES OF SELENIUM.

290. *Oxide of Selenium.*— $SeO$ ;  $39.6+8=47.6$ . Oxide of selenium is a colourless gas, which emits a peculiar and powerful odour, resembling decayed horseradish.

291. *Selenious Acid.*— $SeO_2$ ;  $39.6+16=55.6$ . Selenious acid may be obtained as a hydrate in pris-

(20N+200)

That of Sulphuric acid being  
but 1.85.  
and its boiling point  $620^{\circ}$

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matic crystals. It has the odour of chlorine, is very soluble, and is a powerful acid.

292. *Selenic Acid.*— $\text{SeO}_3$ ;  $39.6+24=63.6$ . The most concentrated form in which selenic acid has been obtained, is that of a liquid hydrate, containing an atom of water. Its specific gravity is 2.6, its boiling point  $536^\circ$ , and it is decomposed if further concentrated. It is a powerful acid, and when heated oxidizes gold, but not platinum. Its compounds with the bases so closely resemble the corresponding sulphates in colour, crystalline form, and external characters, that they are only to be known by being decomposed by chlorohydric acid, and detonating on ignited charcoal.

## OXIDES OF PHOSPHORUS.

293. *Oxide of Phosphorus.*— $\text{P}_2\text{O}_5$ ;  $47.1+8=55.1$ . Oxide of phosphorus is a solid of a red colour, insoluble, tasteless, and inodorous; permanent in the air at  $662^\circ \text{F.}$ , but taking fire at a low red heat.

294. *Phosphorous Acid.*— $\text{P}_2\text{O}_3$ ;  $31.4+24=55.4$ . This acid may be prepared by subliming phosphorus through bichloride of mercury in a glass tube. A limpid liquid is formed, which is a chloride of phosphorus, and which is converted into phosphorous and chlorohydric acids by the action of water. Phosphorous acid has a sour taste, and a smell somewhat resembling that of garlic. It has a powerful affinity for oxygen, and precipitates several of the metals from their salts in a metallic form. When anhydrous it takes fire upon being heated in the open air.

295. *Phosphoric Acid.*— $\text{P}_2\text{O}_5$ ;  $31.4+40=71.4$ . This acid may be prepared by oxidating phosphorus by means of nitric acid, and by decomposing the bisphosphate of lime by means of ammonia.

Phosphoric acid is colourless; it reddens litmus paper and neutralizes alkalies; it is intensely sour to the taste, but does not destroy the texture of the

Some doubt as to this  
as about: air always  
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generally called  $\frac{1}{2}$  to 1  
but  $23 \times 3 = 69 \frac{1}{2}$   
more w'd be 80 instad  
of 77-

Globe to weigh air  
100 cubic in 31.011  
27

skin like sulphuric and nitric acids. When evaporated at  $300^{\circ}$  it becomes a dark thick liquid, like treacle, and consists of one atom of phosphoric acid and three atoms of water. This hydrate has been obtained in thin crystalline plates by careful evaporation *in vacuo*.

When this terhydrated phosphoric acid is heated to  $415^{\circ}$  it parts with one atom of water. When heated to a red heat it parts with two atoms, and hardens in cooling into a brittle, transparent solid, known by the name of glacial phosphoric acid, which is highly deliquescent, and can only be preserved in carefully closed glass or stone bottles. An anhydrous phosphoric acid is formed when phosphorus is burnt in dry oxygen gas.

The water, combined with phosphoric acid, appears to form with it three distinct chemical compounds, possessed of distinct and peculiar properties. The anhydrous and the glacial acid appear to be identical in their chemical relations, and form salts containing one atom of base and one of acid. They have been called metaphosphoric acid. The bihydrated phosphoric acid is distinguished by its property of forming di-salts, containing an atom of acid and two atoms of base. In those cases in which it unites with a single atom of base, an additional atom of water appears to be an essential element of the salt. This modification of the acid has received the name of pyrophosphoric acid. The ordinary phosphoric acid has a strong tendency to form salts containing three atoms of base, whether those atoms be altogether alkaline, or part alkali and part basic water. The salts formed by these modifications of phosphoric acid with the same base are likewise of modified characters, and have been regarded as striking instances of the law of isomerism.

There is another oxide of phosphorus, the hypophosphorous acid, which consists of two atoms of phosphorus, 31.4, and one of oxygen, 8=39.4.



## OXIDES OF NITROGEN.

296. *Atmospheric Air*.—Although atmospheric air is not to be regarded as a chemical union of its elements, it belongs under this head.

The atmosphere is a mixture of 23 parts by weight, or 208 in volume, of oxygen, with 77 parts by weight, or 792 in volume, of nitrogen. They are not, therefore, combined in the ratio of an even multiple of their atomic numbers, which is the distinction between a mechanical mixture and a true combination. The atmosphere possesses all the characters of a mere mechanical mixture. There is no change in the form, bulk, or other qualities of its elements. All the bodies which have an affinity for oxygen attract it as easily from the air as if the nitrogen were not present. A mixture of the two gases in the same proportions has the same density and refractive power, and agrees in all respects with atmospheric air.

297. If a thin globe of the capacity of 100 cubic inches, provided with a proper stopcock, be weighed, and then carefully exhausted of its air by an air pump, it will be found that it has lost 31.0117 grains, when the thermometer stands at 60° F., (15½° C.), and the barometer at 30 inches. One hundred cubic inches of water, at the same temperature and pressure, weigh 25245.8 grains. The atmosphere at the earth's surface is, therefore, 815 times lighter than water. It is also nearly 11065 times lighter than mercury.

298. The weight of the air is adopted as the standard with which the weight of all other aeriform fluids is compared. Its specific gravity is, therefore, assumed to be unity.

If a glass tube 32 or 33 inches long be filled with mercury, and then inverted in a vessel of mercury,

Some doubt as to this,  
as atmosp. air always  
the same, but cleared  
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generally called 4 to 1  
but  $23 \times 3 = 69 \frac{1}{2}$   
more w<sup>d</sup> be 80 instead  
of 77-

Globe to weigh air  
100 cubic in 31.0117

it will be found that a column of the fluid metal, 30 inches high, will be sustained in the tube, by the pressure of the atmosphere on the surface of the mercury in the vessel.

The weight of a column of mercury one inch square, and 30 inches high, is nearly 15 pounds, which is, therefore, the pressure of the atmosphere at the earth's surface; but, as it presses equally in all directions, it is not felt by us. The weight of this column of mercury being a counterpoise to the weight of the atmospheric column, it follows that the height of an atmosphere of the same density throughout as at the surface would be 30 inches  $\times 11065$ , or  $5\frac{1}{2}$  miles.

299. But as, in consequence of its elasticity, the density of the air decreases as we ascend, the actual height of the atmosphere is supposed to be about 45 miles. The elastic force which separates the particles becomes at last so feeble as to be no more than equal to the attraction of gravitation; and this equality limits the further separation of the particles, and determines the height of the atmosphere.

300. In virtue of the law of elastic fluids, that the density is directly as the pressure, a volume of air which, under a pressure of one pound, occupies 100 cubic inches, will be compressed into half the space by double the pressure, and expand into twice the volume under half the pressure; and it is a consequence of this law and of the law of gravity, that the density of the atmosphere decreases in a geometrical ratio when the height increases in an arithmetical one. It has been found by experiments made on the Puy de Dome—a mountain in Auvergne in France—that the barometer in ascending a height of 3000 feet falls from 28 to 24.7 inches. The twelfth term in a decreasing geometrical series, having the ratio 28 to 24.7, is 7.038, or nearly 7 inches. At the height of  $3000 \times 12 = 36000$  feet, or

All mountains that  
reach above the line  
covered by perfect seas

ΕΥΔΙΑ καλον οαι δ  
ΜΕΤΡΟΝ μεασμα

nearly 7 miles, the density of the air is therefore one fourth that of the surface, and the following table is founded on this calculation.

Altitude in miles.	Corresponding density.
0 . . . . .	1
7 . . . . .	$\frac{1}{4}$
14 . . . . .	$\frac{1}{16}$
21 . . . . .	$\frac{1}{64}$
28 . . . . .	$\frac{1}{256}$
35 . . . . .	$\frac{1}{1024}$
42 . . . . .	$\frac{1}{4096}$
49 . . . . .	$\frac{1}{16384}$

301. As the radiant heat of the sun passes through the air without any absorption, and does not therefore heat it, the atmosphere must receive its heat from contact with the earth.

The decreasing density of the atmosphere being a necessary consequence of its constitution as an elastic fluid; and also its capacity for heat being, as has been stated in the chapter on caloric, increased by rarefaction, and the earth being the source of that heat, it follows that the sensible heat of the atmosphere must decrease as the latent or specific heat increases; that is, in proportion to the height above the earth. For if we forcibly expand a stratum of air at any distance from the surface, it will rise until it reaches an equally rarefied stratum; its specific heat being increased, a sufficient portion of the sensible heat will be necessarily absorbed to supply it, and the temperature will fall. So, on the other hand, if a portion be forcibly condensed, it will sink until it gain its proper level; the specific heat being lessened, all the caloric thus disengaged will become free, and raise the temperature. It has accordingly been found that in ascending into the atmosphere the temperature falls one degree of Fahrenheit for about every 352 feet of height. There is conse-

\* The difference in the wholesomeness of air arises therefore from no actual change in the air, but from mixture with foreign ingredients - Smoak sand, Humidity &c



quently in every latitude a point at which the thermometer never rises above  $32^{\circ}$ , or where ice does not melt. This point is called the point of perpetual congelation, and the line drawn through all these points, the line of perpetual congelation.

The following table shows the height of this point in different latitudes.

Lat.	Feet.	Lat.	Feet.
0	15.207	50	6.334
10	14.764	60	3.818
20	13.478	70	1.778
30	11.484	80	.457
40	9.001	85	.117

302. The atmosphere contains from 4 to 6-10,000ths of carbonic acid; a minute quantity of light carburetted hydrogen gas, and a variable quantity of aqueous vapour. The carbonic acid is greater in summer than in winter, and by night than by day.

303. The analysis of atmospheric air, is readily performed, in several ways. Phosphorus undergoes a slow combustion, at ordinary temperatures, and will abstract all the oxygen from a vessel of air in about thirty hours. Thin filings or shavings of lead rapidly combine with oxygen, and entirely remove it from the air. Oxygen combines with twice its volume of hydrogen to form water. When, therefore, a mixture of equal measures of atmospheric air and hydrogen, contained in a strong and graduated glass tube, is exploded by means of the electric spark, one third of the diminution in the volume is due to oxygen gas. The deutoxide of nitrogen also furnishes a ready means of analysis which will be noticed when treating of that substance.

304. The art of determining the purity of the air by these and other means, is called *Eudiometry*, and the instruments for ascertaining it *Eudiometers*, or measurers of pure air. After repeated experi-

*All mountains that  
reach above this line  
covered by perpetual snow*

*εὐδία καθαροῦ αἵματος  
μετρησῶν*

ments in every variety of situation, it is fully ascertained that the proportions of the two gases do not sensibly vary on the top of the highest mountains, in the deepest forests, in the midst of the most crowded cities, over the ocean, and in the open verdant plains. \*

305. As respiration, combustion, and a great variety of other processes, are continually consuming the oxygen of the atmosphere, there must be some source of supply commensurate with these drains. This exists in the vegetable kingdom. Plants during the day absorb carbonic acid from the air, and evolve its oxygen; the carbon constituting their food. During night this process is reversed; but it has been ascertained that in the whole twenty-four hours they give out more oxygen than they absorb, and thus probably repair the continual waste from other causes.

306. *Protoxide of Nitrogen. Nitrous Oxide, NO*;  $14.15 + 8 = 22.15$ . This gas is prepared by heating the nitrate of ammonia in a retort to  $400^{\circ}$  or  $500^{\circ}$  F., at which temperature it fuses, and is rapidly decomposed. The following formula will explain the nature of the change which takes place.

Nitrate of ammonia consists of

<i>val of</i>				
1, nitric acid	=	1	nitrogen	$14.15 + 5$ oxygen = $40 = 54.15$
1, ammonia	=	1	nitrogen	$14.15 + 3$ hydrogen = $3 = 17.15$
				$71.30$

When this salt is decomposed, the 3 atoms of hydrogen combine with 3 atoms of oxygen and form 3 atoms of water, while the remaining 2 atoms of oxygen combine with the 2 atoms of nitrogen and form 2 atoms of protoxide of nitrogen. It thus appears that 71.3 grains of nitrate of ammonia will yield 44.3 grains of the protoxide.

307. Protoxide of nitrogen is a colourless gas

\* The difference in the wholesomeness of air arises therefore from no actual change in the air, but from mixture with foreign ingredients - Smoak, Humidity &c

Lead

which does not affect vegetable blues. Water dissolves its own bulk of it, acquires a sweet taste, and a faint, agreeable odour; but gives out the gas unchanged at  $212^{\circ}$ .

Many substances, when previously kindled, burn in this gas with great splendour. Iron wire, charcoal, phosphorus, and sulphur, when kindled, burn with as much splendour as in oxygen gas, and the glowing wick of a taper is immediately rekindled. It may be decomposed by a succession of electrical sparks, or by passing it through a red hot tube of porcelain. It is in both cases resolved into oxygen, nitrogen, and nitrous acid. When 100 measures of the protoxide and 100 of hydrogen are detonated together, both gases disappear, water is formed, and 100 measures of nitrogen gas remain. As the 100 measures of hydrogen combine with 50 measures of oxygen to form water, it is evident that 100 measures of protoxide consist of 100 nitrogen and 50 oxygen condensed into 100. Its specific gravity is thus easily determined to be 1.5239; for

100 cubic inches of nitrogen weigh	30.1650 grs.
50 do. oxygen	17.0936
100 do. protoxide of nitrogen	47.2586

308. Protoxide of nitrogen will support respiration for a short time, not exceeding 3 or 4 minutes, and produces a temporary delirium, generally accompanied by the most agreeable feelings of excitement, which soon, however, subside. From four to nine quarts are breathed from a silk bag, and a few deep inspirations will be followed by feelings resembling those of the earlier stages of intoxication. These effects are not uniform, and they are occasionally of an unpleasant and alarming nature.

Under a pressure of 50 atmospheres the protoxide is condensed into a transparent liquid.

*all mountains that  
reach above the line  
covered by perfect snow*

*εὐδία calm air &  
μεῖρον measure.*

309. *Deutoxide of Nitrogen. Binoxide of Nitrogen. Nitric Oxide.*— $\text{NO}_2$ ;  $14.15+16=30.15$ . The best method of preparing this gas, is by the action of nitric acid of the specific gravity of 1.2 on copper turnings. The nitric acid parts with three atoms of its oxygen to the copper, and an atom of nitric oxide gas escapes. Three atoms of protoxide of copper are formed, which unite with three atoms of the remaining nitric acid to form the nitrate of copper.

310. The deutoxide is a colourless irrespirable gas, which excites strong and dangerous spasms in the glottis.

Very few inflammable substances burn in this gas; burning sulphur and a lighted taper are extinguished by it, but charcoal and phosphorus, if immersed when in vivid combustion, burn with increased brilliancy. With an equal bulk of hydrogen it forms a mixture which burns quietly with a greenish-white flame. *with Hydrog.*

The deutoxide of nitrogen is partially decomposed by a succession of electrical sparks, and by passing through red-hot tubes. If potassium is heated in 100 measures of this gas, it is converted into potassa, the volume of the gas is reduced one half, and pure nitrogen is left in the vessel. The quantity of oxygen that combines with the potassium is 50 measures, so that the deutoxide is composed of equal volumes of nitrogen and oxygen, which unite without any change of bulk; its specific gravity is therefore 1.0375.

311. Deutoxide of nitrogen is distinguished from all other gases, by the formation of red vapours of nitrous acid, whenever it comes in contact with oxygen gas. This property renders it a very convenient test of the presence of oxygen, and useful in the analysis of atmospheric air. When 100 measures of this gas are introduced into a wide vessel containing 100 measures of atmospheric air, the red fumes are



speedily formed and absorbed by the water, and one fourth of the diminution which takes place is oxygen gas.

Both the protoxide and the deutoxide of nitrogen form compounds of considerable permanence with the pure alkalies.

312. *Hyponitrous Acid.*— $\text{NO}_3$ ;  $14.15 + 24 = 38.15$ . This acid may be formed by mixing 400 measures of deutoxide of nitrogen with 100 measure of oxygen, in a glass tube containing a strong solution of pure potassa and inverted over mercury. The acid which is generated unites with the potassa and forms a hyponitrite of potassa.

The hyponitrous acid is a liquid, colourless at  $0^\circ\text{F}$ . and green at common temperatures. In open vessels it rapidly passes off in orange vapours of the density of 1.72. When mixed with water it is decomposed into nitric acid and deutoxide of nitrogen.

313. *Nitrous Acid.*— $\text{NO}_4$ ;  $14.15 + 32 = 46.15$ . When deutoxide of nitrogen is mixed with oxygen, red fumes of nitrous acid are always formed. 200 measures of the deutoxide (100 nitrogen + 100 oxygen) unite with 100 of oxygen and contract into 100 measures, so that the specific gravity of nitrous acid gas is 3.1775.

Nitrous acid vapour is condensed into a liquid at a low temperature, and the acid may be obtained in a liquid form by heating carefully dried nitrate of lead in an earthen retort to a red heat, and collecting the vapours of nitrous acid, which are formed, in a vessel surrounded by a freezing mixture. The liquid acid is highly pungent and corrosive; its colour at common temperatures is orange-red, at  $32^\circ$  is yellow, and at  $0^\circ$  it is colourless. Its density is 1.451, and its boiling point  $82^\circ$ . Nitrous acid gas is highly irrespirable and excites violent spasms of the glottis. It extinguishes burning sulphur, but phosphorus and a taper will burn in it with great brilliancy.

Nitrous acid readily parts with its oxygen to the more oxidizable bases, and is usually converted thereby into deutoxide. It is decomposed, and yields oxygen and nitrogen gases by being transmitted through a red-hot porcelain tube.

When nitrous acid gas is passed into water, it is decomposed into nitric acid and the deutoxide, the latter of which escapes with effervescence. The solution first becomes blue, then blueish-green, green, yellow, and orange, according to the relative quantity of nitric or nitrous acids. The more nitric acid the solution contains, the greater is the quantity of nitrous acid which it will retain without decomposition. When nitrous acid gas is heated, its colour gradually deepens, until it becomes at last absolutely black.

314. *Nitric Acid.*— $\text{NO}_2$ ;  $14.15 + 40 = 54.15$ . Nitric acid may be formed by passing a succession of electric sparks through a mixture of oxygen and nitrogen gases in which moisture is present. It may also be formed by slowly adding deutoxide of nitrogen to an excess of oxygen gas over water. It has been proved by this means that the acid consists of 100 volumes of nitrogen and 250 of oxygen.

Nitric acid cannot exist in an insulated state, and the most concentrated form in which it can be obtained is a combination of two atoms of acid and three of water.

The nitric acid of commerce is usually called aqua fortis, and is generally prepared by decomposing the nitrate of potassa by sulphuric acid. The presence of water is essential to the process, as without it a considerable portion of the nitric acid is decomposed; for it is driven off from the potassa by the superior affinity of the sulphuric acid, and not finding the quantity of water which is necessary to its separate existence, is resolved into nitrous acid and oxygen.

315. Nitric acid, in its purest and most concen-

trated form, is a colourless liquid—eminently acid in all its properties—of a specific gravity of 1.5 or 1.51, and containing 20 per cent of water. It emits dense, white, suffocating fumes, and absorbs water from the atmosphere. It boils at  $248^{\circ}$  F., and may be distilled without material change. Dilute nitric acid may be concentrated by heat till it gains the density of 1.42; but if acid of a greater density than this be heated, it is weakened. The strongest nitric acid freezes at  $-50^{\circ}$  F., diluted with half its weight of water it congeals at  $-1\frac{1}{2}^{\circ}$  F. while the addition of a little more water reduces the freezing point to  $-45^{\circ}$  F.

Nitric acid has a great affinity for water, and heat is disengaged when the two are mixed; from this affinity for water it liquefies snow with great rapidity, so that a mixture of 4 parts of concentrated acid, and 7 parts of snow, reduces the thermometer from  $+32^{\circ}$  to  $-30^{\circ}$  F.

Nitric acid acts powerfully on all substances which have much affinity for oxygen. It oxidates nearly all the metals, and acts on tin, copper, and mercury, with great violence. It decomposes all vegetable and animal substances, and imparts to most of them, and particularly to the skin and nails, a permanent yellow stain. It acidifies sulphur and phosphorus, and when flung on burning charcoal greatly increases the brilliancy of the combustion.

*Ammonia is in  
Vol 2 alp 270*

## OXIDES OF HYDROGEN.

316. *Water*.  $\text{HO}$ ;  $1+8=9$ .—Water is a transparent, colourless, inodorous, and tasteless substance, which is solid below  $32^{\circ}$  and fluid at ordinary temperatures. It refracts light powerfully, and conducts heat very slowly. In its fluid state it is an imperfect conductor, and in its solid state a non-conductor of electricity. A cubic inch of water at  $62^{\circ}$  F. and